PCT/CH 2004/000461

SCHWEIZERISCHE EIDGENOSSENSCHAFT
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Die beiliegenden Akten stimmen überein mit den ursprünglichen Unterlagen der auf den nächsten Seiten bezeichneten, beim unterzeichneten Amt als Anmeldeamt im Sinne von Art. 10 des Vertrages über die internationale Zusammenarbeit auf dem Gebiet des Patentwesens (PCT) eingegangenen Patentanmeldung.

Attestation

Les documents ci-joints sont conformes aux pièces originales relative à la demande de brevet spécifiée aux pages suivantes, déposées auprès de l'Office soussigné, en tant qu'Office récepteur au sens de l'article 10 du Traité de coopération en matière de brevets (PCT).

Confirmation

It is hereby confirmed that the attached documents are corresponding with the original pages of the international application, as identified on the following pages, filed under Article 10 of the Patent Cooperation Treaty (PCT) at the receiving office named below.

Bern, 21. Juli 2004

Eidgenössisches Institut für Geistiges Eigentum
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Patentverfahren
Administration des brevets
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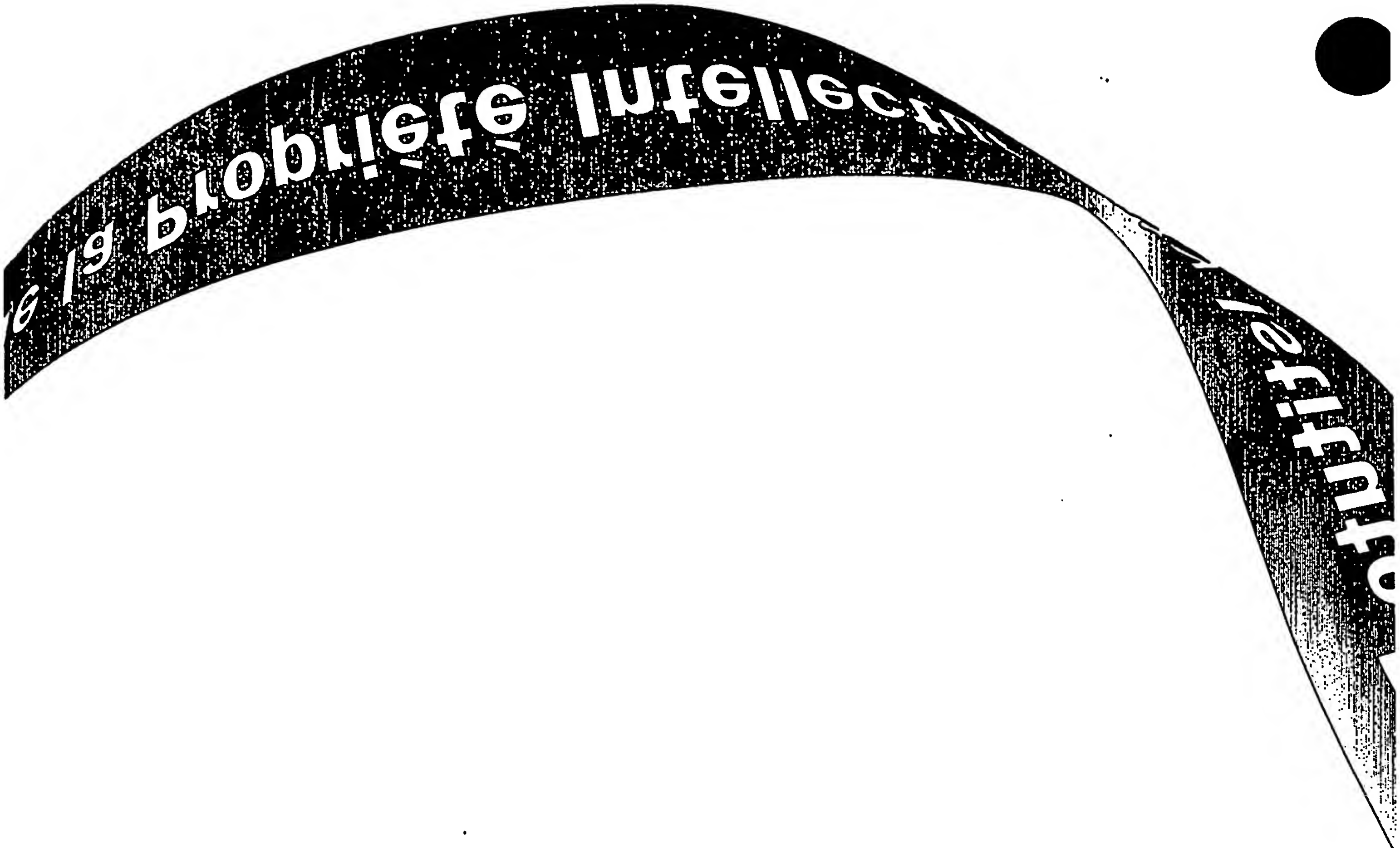
Rolf Hofstetter



Anmeldeamtsexemplar

PCT REQUEST

26981WO-7ST

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0	For receiving Office use only	
0-1	International Application No.	PCT/CH 03 / 00499
0-2	International Filing Date	22. Juli 2003 (22.07.03)
0-3	Name of receiving Office and "PCT International Application"	RO / CH - Internationale Anmeldung PCT
0-4	Form - PCT/RO/101 PCT Request	
0-4-1	Prepared using	PCT-EASY Version 2.92 (updated 01.04.2003)
0-5	Petition The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	Receiving Office (specified by the applicant)	Swiss Federal Intellectual Property Institute (RO/CH)
0-7	Applicant's or agent's file reference	26981WO-7ST
I	Title of invention	INTEGRATED DESALINATION PLANT AND WELL PUMP ARRANGEMENT
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V	**Designation of States**	
V-1	Regional Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	AP: GH GM KE LS MW MZ SD SL SZ TZ UG ZM ZW and any other State which is a Contracting State of the Harare Protocol and of the PCT EA: AM AZ BY KG KZ MD RU TJ TM and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT EP: AT BE BG CH&LI CY CZ DE DK EE ES FI FR GB GR HU IE IT LU MC NL PT RO SE SI SK TR and any other State which is a Contracting State of the European Patent Convention and of the PCT OA: BF BJ CF CG CI CM GA GN GQ GW ML MR NE SN TD TG and any other State which is a member State of OAPI and a Contracting State of the PCT
V-2	National Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH&LI CN CO CR CU CZ DE DK DM DZ EC EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NI NO NZ OM PG PH PL PT RO RU SC SD SE SG SK SL SY TJ TM TN TR TT TZ UA UG US UZ VC VN YU ZA ZM ZW
V-6	**Precautionary Designation Statement** In addition to the designations made under items V-1, V-2 and V-3, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except any designation(s) of the State(s) indicated under item V-6 below. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit.	

PCT REQUEST

26981WO-7ST

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V-6	Exclusion(s) from precautionary designations	NONE	
VI	Priority claim	NONE	
VII-1	International Searching Authority Chosen	European Patent Office (EPO) (ISA/EP)	
VIII	Declarations	Number of declarations	
VIII-1	Declaration as to the identity of the inventor	-	
VIII-2	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent	-	
VIII-3	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application	-	
VIII-4	Declaration of inventorship (only for the purposes of the designation of the United States of America)	- 1*	
RO VIII-5	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty	-	
IX	Check list	number of sheets	electronic file(s) attached
IX-1	Request (including declaration sheets)	4	-
IX-2	Description	13	-
IX-3	Claims	5	-
IX-4	Abstract	1	EZABST00.TXT
IX-5	Drawings	3	-
IX-7	TOTAL	26	
	Accompanying Items	paper document(s) attached	electronic file(s) attached
IX-8	Fee calculation sheet	✓	-
IX-9	Original separate power of attorney	✓	-
IX-17	PCT-EASY diskette	-	Diskette
IX-18	Other (specified):	separate Form PCT/RO/101 (declaration sheet (iv))	-
IX-19	Figure of the drawings which should accompany the abstract	1	
IX-20	Language of filing of the international application	English	
X-1	Signature of applicant, agent or common representative		
X-1-1	Name	AMMANN PATENT ATTORNEYS LTD. BERNE	
X-1-2	Name of signatory	M. Störzbach	

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10-2	Drawings:	
10-2-1	Received	
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10-3	Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application	
10-4	Date of timely receipt of the required corrections under PCT Article 11(2)	
10-5	International Searching Authority	ISA/EP
10-6	Transmittal of search copy delayed until search fee is paid	

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11-1	Date of receipt of the record copy by the International Bureau	

INTEGRATED DESALINATION PLANT AND WELL PUMP ARRANGEMENT

BACKGROUND

The present invention relates to a system for drawing water from wells and treating the water drawn thereof. Specifically, the present invention is directed towards the integration of desalination plants with well pumping arrangements in order to achieve a sweet water productivity that is greater than 90% and avoids the problem of brine disposal.

The availability of safe drinking water is rapidly decreasing due to contamination of sweet water reserves, brought about by excessive non-sustainable supply. As a result, the water from these sources often needs to be purified before it can be used for potable purposes. This process of purification is referred to as water treatment.

A typical water treatment process is a two-stage process. First stage is the drawing of water from the natural/artificial sources such as wells, rivers and even the sea. Water is drawn from these sources using various types of devices. Specifically, for well water, well pumps are used to draw water from the well to the ground level. Water drawn from the well is often saline in nature. Hence, the second stage of water treatment is the process to remove contaminants and dissolved salts from the water obtained in the first stage.

The second stage is further segmented into various processes. In particular, water is first filtered to remove large sized contaminants such as silt, and various microorganisms. This stage of water treatment mimics the

natural filtration of water as it moves through the ground. Filtration is followed by various treatments such as the application of chemical disinfectants and/or UV radiation so as to kill or neutralise the more dangerous bacterial and viral contaminants.

The remaining solutes and active contaminants that have not yet been removed or neutralised are extracted, where possible, using various forms of membrane technology, dialysis etc. The salt component removal is referred to as the process of desalination. Desalination is one of the more costly and high energy aspects of the water treatment process. Hence, improvements in the desalination process have a substantial impact on the availability of water. Desalination can be performed using a number of techniques that include distillation and reverse osmosis (RO).

Distillation is the traditional method of desalination. It involves evaporation and condensation of the saline water to remove dissolved salts and other minerals from water. The purified water obtained is exempt of salt and all other minerals and as such is totally unsafe for drinking. It can be re-constituted, but requires further processing. In addition, distillation is a very expensive process even when the latest multistage vacuum techniques are employed. The equipment is capital intensive and the process involves high-energy consumption. Also, there is always a substantial volume of hot brine produced that requires disposal.

Reverse osmosis based desalination consumes less energy and is gaining popularity for small and medium scale desalination. A RO-based desalination unit comprises a high-pressure pump, a module divided into two chambers by a semi-

permeable membrane and a pressure control unit. The saline water is pumped into the module using a pressure-amplifying device such as a high-pressure pump. The semi-permeable membrane permits a water flux across the membrane, but inhibits the transport of salts. The water (permeate) in the low-pressure chamber beyond the membrane is desalinated, and the salt is left behind in the high-pressure chamber in front of the membrane. The concentrated salt water in this high-pressure chamber leaves the module via a pressure control valve. The desalinated water (hereinafter referred to as sweet water) can easily be polished for various end uses such as drinking or agricultural purposes. The concentrated salt solution (hereinafter referred to as brine) is the waste product that requires disposal.

The brine produced in the RO-based desalination process has a higher salt concentration than that of the feedstock. Unless there is a clear use for this brine it can represent a serious nuisance value, as it has to be disposed of. In particular, the brine cannot be poured onto the land or allowed to contaminate sweet water reserves. Also, the energy stored in the high-pressure brine line is lost if the brine is just jetted into the environment. One way of avoiding the energy loss is to use a hydraulic energy recovery system mounted on the brine line. This solves the problem of substantial energy recovery, but does not provide a solution concerning the brine disposal.

One such energy recovery unit is described in US patent 6540487, titled „Pressure exchanger with an anti-cavitation pressure relief system in the end covers". The patent describes a dynamic pressure exchanger based on the classic liquid piston principle that transfers pressure from

the high-pressure liquid to a low-pressure liquid. The device is used in the desalination units for increasing the pressure of seawater by profiting from the residual pressure in the brine line. The result is a lower power consumption of the high-pressure pump used in the desalination unit, because the pump must handle a lower flow rate.

Another energy recovery unit is described in British patent application GB02363741 titled "Energy recovery during desalination of seawater". The patent describes an energy recovery device comprising a tank with two compartments separated by a movable wall. The buffer tank has a first compartment for the brine water and second compartment for the seawater produced along with the sweet water. To assist the flow of seawater out of the second compartment into the RO unit, a load is arranged to act on the wall. The brine solution replaces the seawater from the second compartment due to the application of pressure on account of the load attached to the movable wall. Thus, this system converts the energy in the form of brine pressure into useful work in the RO unit by driving the seawater into the RO unit.

While the stored energy in the brine solution is used to reduce energy consumption in the desalination unit, the brine solution still needs to be disposed of after passing through the energy recovery unit. Hence, there is a need for a method and system, which avoids the disposal of the brine solution into the environment.

Apart from the problem of disposal of the brine solution, there are various other problems with the existing water treatment processes. In particular, there are problems associated with the method used for drawing water from a

deep well.

Deep wells, such as those that would have to be tapped in many inland arid areas, require the lowering of an electrically driven pump down to the bottom of the well. The performance of the pumps is dependent on the bore size of the well. In particular, a large borehole permits the use of a sufficiently large diameter pump to cope with a high flow rate. However, for deep wells it is unrealistic to drill bore sizes that exceed 200-300 mm and so the mechanical pump that can be lowered down is limited in performance. Thus, the volume of water that can be drawn from a deep well is not very high even if the aquifer has a very large capacity. This problem is very prominent in places far away from the sea and especially in arid regions, which have scarce water resources. The water table in such areas is often found to be very low down necessitating deep wells. Limited water resources imply that these wells must be fully utilised and run at flow rates that are sustainable and yet large enough to satisfy the water requirement.

In light of the drawbacks of the existing art, there is a need for a system that both avoids the requirement for the disposal of large quantities of brine into the environment and efficiently utilises the energy stored in the brine. Further, there is a need for a system and method that permits a greater volume of water to be drawn from the deep well.

SUMMARY

The present invention is directed towards a water treatment method and system for well water.

One object of the present invention is to solve the problem of brine disposal into the environment. The brine is a by-product of desalination within the water treatment system.

Another object of the present invention is to recover energy stored in the brine by-product line by utilising the energy within the water treatment system.

Yet another object of the present invention is to increase the rate at which water can be drawn out of a deep well.

The above objectives are achieved by using a water treatment system comprising a desalination unit and a well pumping unit such that the brine produced as a by-product of desalination is used as feed to run the well pump arrangement.

The well-pumping arrangement comprises one or more well pumps to draw water from the bottom of the well to the Earth's surface. The water drawn is stored in an intermediate reservoir. This water, which is generally saline in nature and not suitable for drinking purposes, is desalinated using a desalination unit. The desalination unit comprises a pumping arrangement that forces the saline water into a separation unit. The separation unit comprises a module separated into two volumes by a semi-permeable membrane. The semi-permeable membrane allows water to pass through while the salts are retained. The water that is passed through is desalinated and used for drinking, while the concentrated salt solution that is left behind is utilised as feed to run the well pump arrangement.

In an embodiment of the present invention, two well pumps in series are lowered down the well. The first well pump is used to increase the volume feed to the second well pump by absorbing the surplus pressure in the brine line. The enhanced feed at lower pressure then drives the second well pump, which sends proportionately more water back to the surface.

BRIEF DESCRIPTION OF THE DRAWINGS

The preferred embodiments of the invention will hereinafter be described in conjunction with the appended drawings provided to illustrate and not to limit the invention, wherein like designations denote like elements, and in which:

FIG.1 illustrates a water treatment system in accordance with a preferred embodiment of the present invention;

FIG.2 illustrates an alternate embodiment of the present invention; and

FIG.3 illustrates another embodiment of the present invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention discloses a water treatment method and system for well water pumping that is designed to avoid disposal of large volumes of brine solution into the environment and reduce energy consumption. The system comprises an integrated desalination unit and well pumping arrangement such that the brine solution produced as a by-product of desalination process acts as feed for the well

pump arrangement.

FIG.1 illustrates a water treatment system 100 in accordance with a preferred embodiment of the present invention. System 100 comprises a well pumping arrangement 102, a desalination unit 104 and a brine line 106 for carrying a feed from desalination unit 104 to well pump arrangement 102.

Well pump arrangement 102 is used to draw water from the well to the surface. Well pump arrangement 102 comprises a well pump to draw water from the well and an exit line 108 to carry the water drawn from the well. Typical well pumping devices include jet pump, centrifugal pump, submersible pump and double-cone device. In a preferred embodiment, a double-cone well pump arrangement (as described in PCT patent application PCT/CH02/00134 titled „Double-cone device and pump") is used for drawing water from the well. It should be apparent to one skilled in the art that any well pump arrangement can be used for drawing water from the well. The water drawn from the well is saline in nature. The saline well water is passed through desalination unit 104.

Desalination unit comprises an intermediate atmospheric pressure reservoir 110, a pumping arrangement 112 and a separation unit 114. Intermediate reservoir 110 stores the saline well water drawn using well pumping arrangement 102. Pumping arrangement 112 can be a high pressure generating system. It forces the saline well water into separation unit 114. In a preferred embodiment, a closed loop pumping arrangement comprising a double-cone device 116 (as described in PCT patent application PCT/CH99/00403 titled „Double-cone for generation of a pressure difference") and a

circulation pump 118 is used. Circulation pump 118 is a low-pressure pump unit, which is connected downstream to double-cone device 116. The closed loop arrangement enables saline water to be pressurised and then transferred to the separation unit 114 at high pressure. The desalination unit in a preferred embodiment is a double-cone device based desalination unit. (As described in patent application PCT/CH99/00403 incorporated herein by reference)

Separation unit 114 is a module divided into two volumes 114A and 114B by a semi-permeable membrane. The semi-permeable membrane allows water to pass through while retaining the dissolved salts present in the saline water. As a result, only sweet water with an extremely low concentration of salt is transferred to volume 114B. The remaining salt solution in volume A becomes more concentrated due to loss of water. Desalinated water is the water suitable for drinking, whilst the remaining salt solution (hereinafter referred to as brine) is the by-product.

The brine is passed through brine line 106 into well pump arrangement 102. Brine line 106, which may optionally contain a booster pump 123, can be any fluid carrying device such as a pipe to carry the brine to well pump arrangement 102. Brine acts as the feed to run well pump arrangement 102. Utilizing brine as the feed also allows system 100 to consume the energy stored in brine, which otherwise would have been wasted. Booster pump 123 can also be used for very deep wells (>500m).

In an alternative embodiment, a pressure regulating valve 124 can also be added to intermediate reservoir 110

for permitting a pressurised feed to pump 122 thereby reducing the power requirement of pump 122.

Further, a bleed 127 is added to brine line 106 so as to check and adjust the brine concentration. Also, a pressure reduction valve 126 is added to reduce the brine pressure to a level prescribed by bleed 127. The bleed (127) is added to brine line (106) so as to check and adjust the brine solution concentration. As the brine concentration rises, it is necessary to open the valve (126) and viceversa. Thus, the inclusion of this bleed (127) allows the monitoring of the brine salt concentration and subsequent adjustment of the valve (126).

Additionally, circulating pumps are used at various places within the water treatment system. Circulating pump is a low pressure, high flow rate pump. Specifically, a circulation pump 120 can be placed between separation unit 114 and pumping arrangement 112 to further facilitate the flow of water into separation unit 114. Similarly, a circulation pump 122 can be placed between intermediate reservoir 110 and pumping arrangement 112 to increase the flow of water to pumping arrangement 112. It should be apparent to one skilled in the art that a plurality of circulation pumps can be placed to increase the flow of water. Further, a variety of circulation pumps can be used.

FIG.2 illustrates an alternative embodiment of the present invention that uses a second separation unit. System 200 comprises a desalination unit 202 and a well pumping arrangement 102. The water drawn by the well pumping arrangement is stored in intermediate reservoir 110. The water flows to pumping arrangement 112 through a separation

unit 204.

Separation unit 204 is a module separated into two volumes 204A and 204B by a semi-permeable membrane. Volume 204A beyond the membrane contains water with a low salt concentration while volume 204B contains brine. The brine is used as the feed for well pumping arrangement 102. Low concentration water is forced into separation unit 114 by pumping arrangement 112. Separation unit 114 produces desalinated water as well as high-pressure brine. The high-pressure brine is sent to volume 204B where the residual pressure is used to drive a dilute salt solution out of the brine across the membrane into the incoming well water in volume 204A. The result of this operation is that the brine concentration is increased substantially and the incoming well water has its salt concentration reduced.

In yet another embodiment, a plurality of well pumps is used to increase the volume of water that can be drawn from the well. FIG.3 illustrates a water treatment system 300 comprising well pumping arrangement 302 being fed by brine and a desalination unit 304. Well pumping arrangement 302 comprises a plurality of well pumps. Specifically, if two double-cone devices for well pumping are used, then a first double-cone device 302A can be used to supplement the available volume of water that can be used for driving the second double-cone device for well pumping 302B. This latter pump sends the water to ground level.

The first pump 302A converts the low volume, high-pressure brine to a lower pressure, higher volume feed capable of driving the well pump 302B. For example, the brine feed pressure can be of the order of 60 bar, whilst

the pressure required to pump the water to the surface is approximately 20 bar. Hence, the surplus 40 bar can be used to increase the volume of the available feed needed to drive the pump 302B.

This technique of using two well pumps in series can yield almost twice the sweet water product volume per unit energy input when compared with the existing systems.

It should be apparent to one skilled in the art that modifications described in system 100 can also be applied to the water treatment system 300. Further, well pumping devices other than the double-cone device for well pumping can also be used to enhance the volume of water drawn from the well.

The present invention utilises brine solution within the system. As a result, the brine is not disposed of into the environment, thus preventing pollution. Further, the energy stored within the brine line is recovered, which results in reduced energy consumption.

All the systems described above are well suited to water production in arid regions that have scarce water resources and where the water table is found at deep levels.

While the preferred embodiments of the invention have been illustrated and described, it will be clear that the invention is not limited to these embodiments only. Numerous modifications, changes, variations, substitutions and equivalents will be apparent to those skilled in the art without departing from the spirit and scope of the invention as described in the claims.

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CLAIMS

1. A water treatment system (100) comprising:

   a. a well pump arrangement (102) for drawing saline water from a well;

   b. a desalination unit (104) for separating saline water into desalinated water and brine solution, the desalination unit further comprising:

      i. an intermediate reservoir (110) for storing saline water;

      ii. a pumping arrangement (112) to pressurize the saline water obtained from the intermediate reservoir; and

      iii. a separating unit (114) to separate the pressurized saline water into sweet water and brine solution;

   c. a brine line (106) for carrying the brine solution from the separating unit to the well pump arrangement;

   whereby the system avoids disposal of brine solution into the environment.

2. The system according to claim 1, wherein the well pump arrangement for drawing saline water from a well comprises:

   a. a first double-cone device (302A) to convert a low flow rate high pressure brine feed into a lower pressure

higher volume feed using the available well water; and

b. at least one second double-cone device (302B) to utilise the enhanced feed so as to draw even more water from the well onto the ground level;

whereby the well pump arrangement increases the volume of water that can be drawn from a well.

3. The system according to claim 1, wherein the pumping arrangement to pressurize the saline water is a closed loop comprising:

a. a double-cone device (116) for pressurizing the saline water obtained from the intermediate reservoir (110) and

b. a circulating pump (122) connected to the inlet of the double-cone device to improve the flow of the saline water in the closed loop.

4. The system according to claim 1, further comprising a second separation unit (204) that utilises the pressure in brine to dilute water from the intermediate reservoir, yielding a lower concentration saline water and a more concentrated brine solution,

wherein the more concentrated brine solution is used as feed for the well pump arrangement,

wherein the lower concentration saline water flows to the closed loop pumping arrangement.

5. The system according to claim 1, further comprising a circulating pump (121) to increase the flow of saline water from the intermediate reservoir to pumping arrangement (112).

6. The system according to claim 1, further comprising a circulating pump (120) to boost the pressure from the outlet of the pumping arrangement to separation unit (114).

7. The system according to claim 1, further comprising one or more pressure regulating valves (124) attached to intermediate reservoir (110), so as to supplement the feed pressure to the high pressure pump system.

8. The system according to claim 1, further comprising one or more bleeds (127) attached to brine line (106), so as to monitor the brine concentration.

9. The system according to claim 8, further comprising a pressure reduction valve (126), wherein the pressure reduction valve reduces the pressure of the brine to a level prescribed by bleed (127).

10. A well pump arrangement designed to enhance the volume of water that can be pumped from the well by utilising any surplus pressure in the brine line, the well pump arrangement (302) comprising:

a. a first well pump (302A) to convert the excess brine line pressure into additional drawn water; and

b. at least one second well pump (302B) to draw the

enhanced volume of water from the well onto the surface.

11. The system according to claim 10, wherein the first well pump is a double-cone device.

12. The system according to claim 10, wherein the second well pump is a double-cone device.

13. A method for integrating desalination unit and well pump arrangement to obtain sweet water, the method comprising the steps of:

a. drawing saline water from a well using the well pump arrangement;

b. passing the saline water through the desalination unit to obtain sweet water and brine; and

c. utilising the brine as feed to run the well pump arrangement;

whereby the method avoids disposal of brine solution into the environment.

14. The method according to claim 13, wherein the step of utilising the brine as feed to run the well pump arrangement further comprises the step of diluting the brine solution with well water to prevent build up of the salt concentration.

15. The method according to claim 13, wherein the step of drawing saline water from the well using well pump

arrangement further comprises the step of converting a low volume saline water into a higher volume saline water.

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ABSTRACT

The present invention deals with a water treatment system to desalinate well water. The system comprises a well pump arrangement and a desalination unit such that the brine solution produced as a by-product of desalination is used as feed to run the well pump arrangement. The system avoids disposal of large volumes of brine into the environment thereby greatly reducing pollution. The system is designed to cope with various well depths down to more than 1000m.

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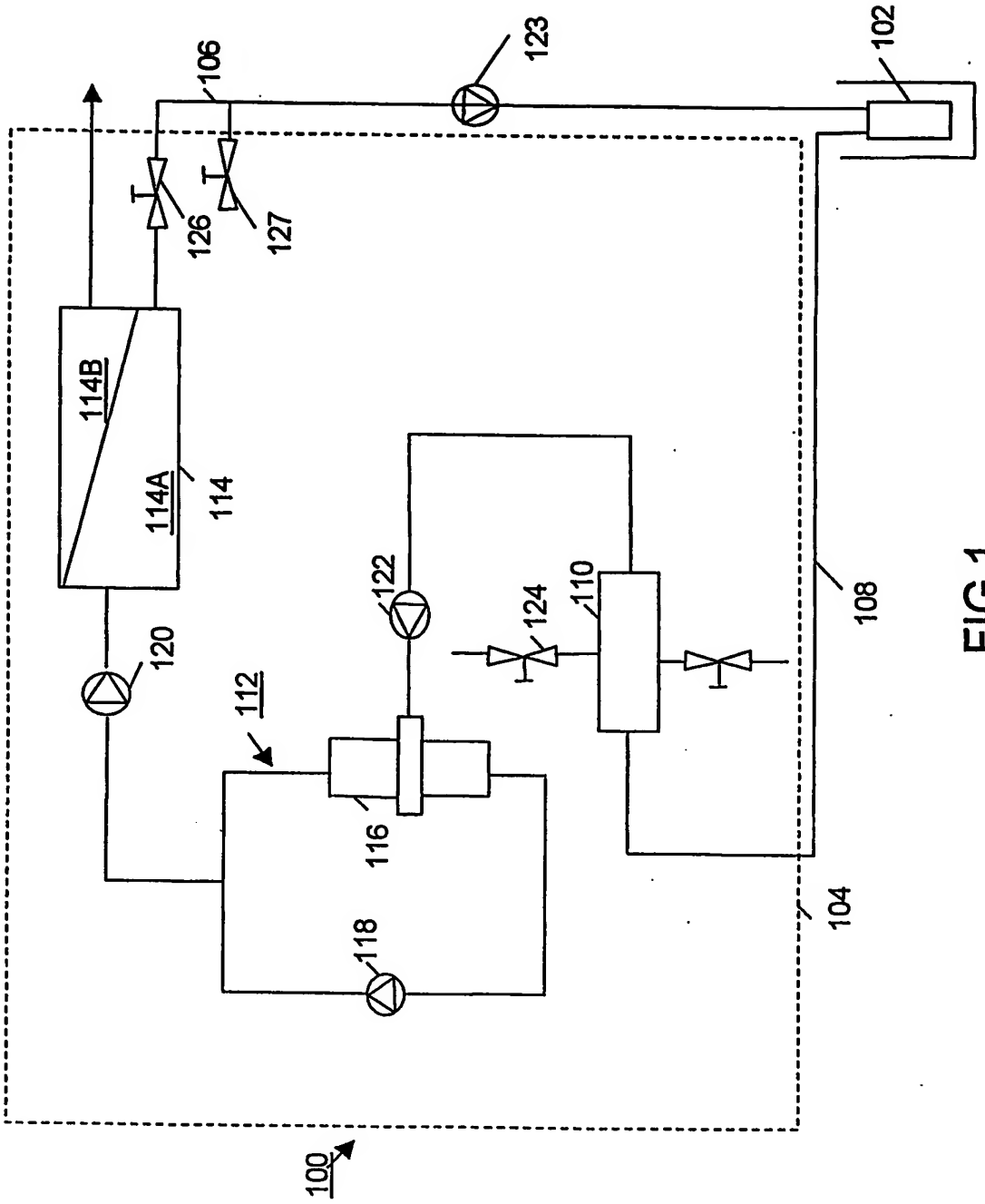
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FIG.1

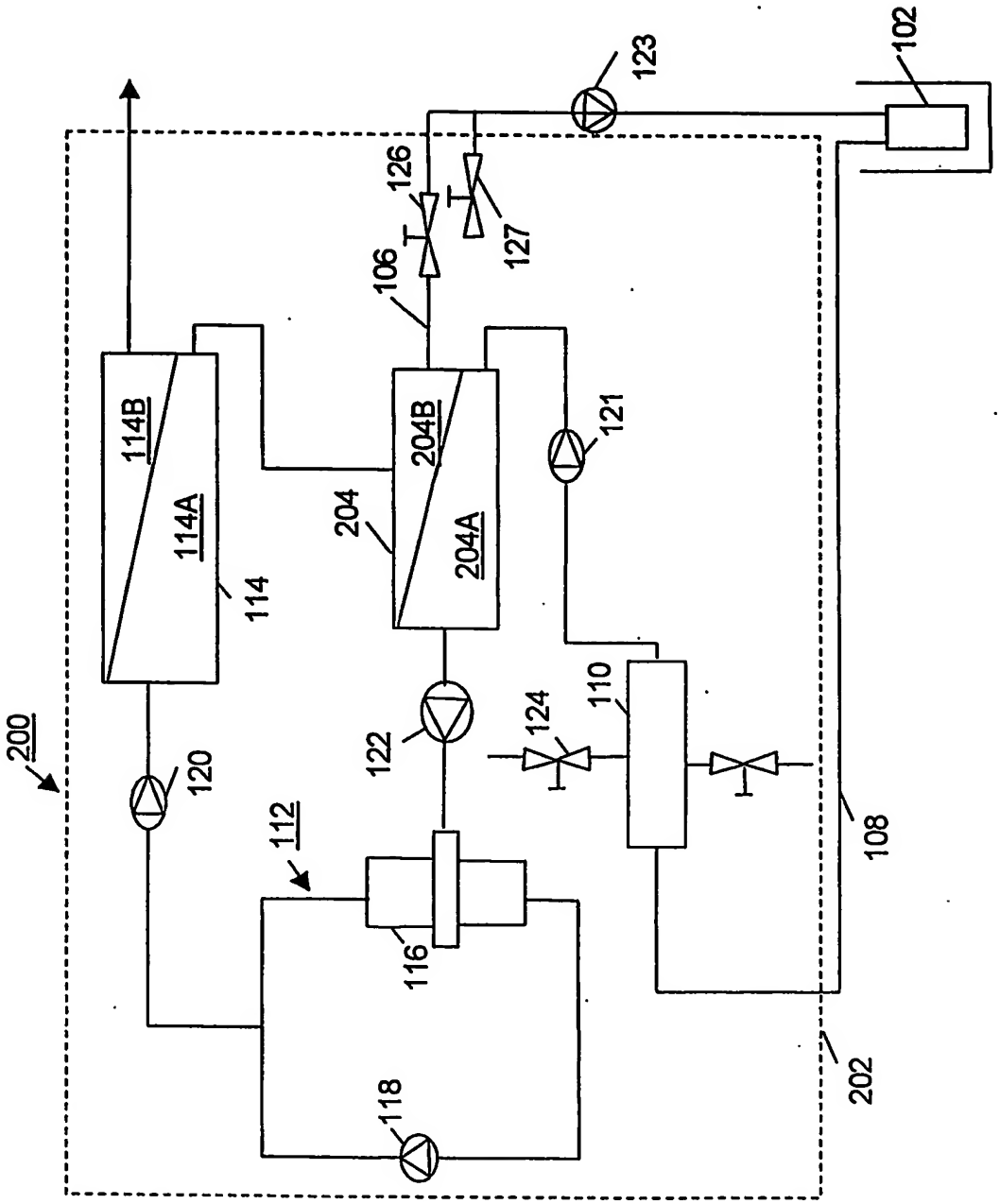
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FIG.2

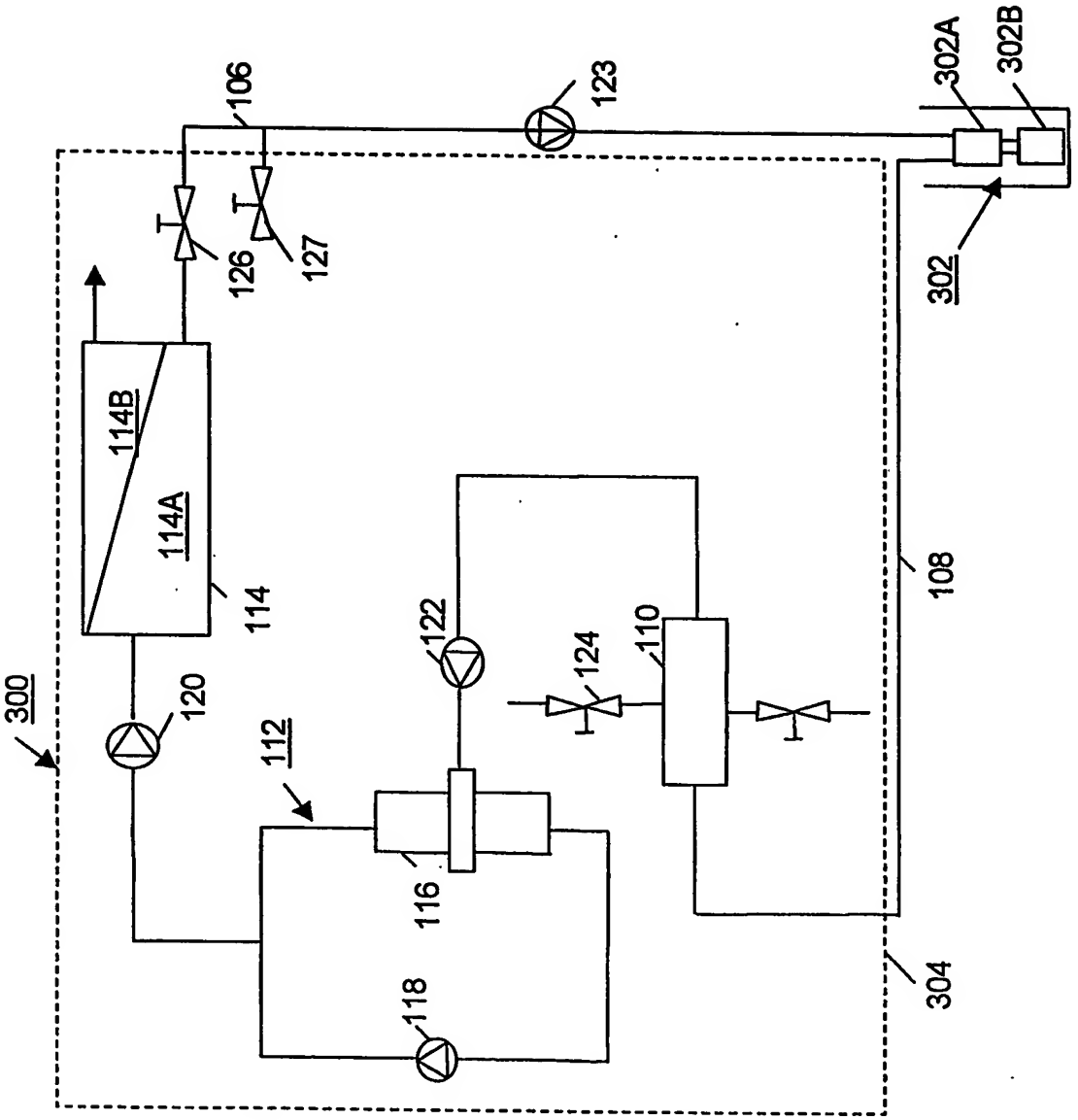
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FIG.3